ABOVEGROUND BIOMASS OF LOBLOLLY PINE IN A NATURAL, UNEVEN-AGED SAWTIMBER STAND IN CENTRAL ALABAMA

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Abstract

Aboveground biomass of 41 loblolly pine trees 6 to 20 inches d.b.h. was determined and equations were developed to predict green and dry weight of the tree and its components from total tree height and d.b.h. The average complete loblolly pine was 51 percent water, 42 percent dry wood, 5 percent dry bark, and 2 percent dry needles. In terms of green or wet weight, 87 percent of the tree was wood, 10 percent was bark, and 3 percent was needles.

Introduction

Total tree utilization is now a reality in the South. Equipment capable of cutting, bunching, skidding, and chipping complete trees has been developed. The chips that are produced are being utilized in the manufacture of composite products and pulp and paper. As increased demand for wood products drives stumpage prices up, utilization of the complete tree will become an economic necessity. This paper gives the aboveground biomass of commercial-sized loblolly pine trees 6 to 20 inches d.b.h. Regression equations are presented for predicting biomass of pulpwood and sawlog trees by tree components. The term total tree in this study refers only to aboveground portions and does not include stump and roots.

Young[10], an enthusiastic advocate of complete-tree utilization, reviewed literature dating back 300 years and found that it was not until after World War II that researchers began to make major contributions to our knowledge of the whole tree. In 1957, Sproull, et al.[9], showed that paper could be manufactured from pulp composed of all tree components. In the past 10 years Young[10] and a group of his colleagues have published over 20 papers on weights, nutrient elements, and pulping characteristics of trees and shrubs growing in the Northeast. They were also instrumental in the development of the modern complete tree concept. The complete tree concept as visualized by Young[10] involves utilization of the entire tree from root hairs to leaf hairs. This concept has been extended to the complete forest including seedlings, saplings, and woody perennials.

Keays[3,4,5,6,7] intensively analyzed the literature on complete tree utilization and published five reports dealing with various tree components. This review revealed that a limited amount of information was available on biomass yields of southern yellow pine, and in particular loblolly pine, the species to be discussed in this paper. Studies on the aboveground components of loblolly pine have attempted to characterize dry matter and nutrient content (Smith[8], Metz and Wells[2]). Most biomass information developed to date has been on relatively small trees; that is, 10 inches d.b.h. or less.

Procedure

Field

A sample of 41 loblolly pine trees was cut on the Oakmulgee District of the Talladega National Forest[1/] near Centerville, Alabama. Sample trees were stratified over eight d.b.h. classes starting at 6 inches and ending at 20 inches. The number of trees per diameter class is shown in Table 1 together with data on merchantable height, total height, age, and form class. Only trees within 0.5 inch of the d.b.h. classes listed were included in the sample (i.e., 5.6-6.5 inches for the 6-inch class, 7.6-8.5 inches for the 8-inch class, etc.).

After felling and limbing, the main stem of each tree was cut into merchantable saw logs 8 to 16 feet long. Saw log merchantability was limited by a 6-inch d.i.b. top, or degrading quality indicators such as large knots. All material above saw log merchantability to a 2-inch top was classed as pulpwood. Disks for moisture content and specific gravity determinations were removed from the butt end of each tree, at each saw log bucking point, and at 4- and 2-inch d.i.b. height levels. These were weighed and calipered with and without bark immediately after being sawn. A representative sample of bark and wood was removed from each disk, weighed, and sealed in a polyethylene bag for laboratory tests.

1/ This study was conducted with the cooperation and financial assistance of the Range, Timber and Wildlife Program Area of Region 8 and the field personnel of the Oakmulgee District of the Talladega National Forest in Alabama.

The crown was cut up and segregated into four categories: (1) large branches ≥ 2.0 inches d.o.b., (2) medium branches ≥ 0.6 inch and ≤ 1.9 inches d.o.b., (3) small branches < 0.6 inch d.o.b., and (4) needles. The needle component was not pure needles, but contained a small amount of branchlets from the current year's growth. The tip of the tree (2 inches d.i.b. to top) was weighed separately, but included as branch material in the analysis. A sample of each crown component was randomly selected from each tree to determine specific gravity and moisture content. Needles were sampled for moisture content only. All moisture content samples were weighed in the field and stored in polyethylene bags.

The four crown components and pulpwood were weighed in the field on a small double-beam balance. Saw logs were weighed individually at a nearby woodyard.

Laboratory

Specific gravity of all sample material was computed on a green volume and ovendry basis. Volumes of large wood sample were determined by the bouyancy method described by Heinrich[1], and volumes of small wood samples and bark were determined by the direct water displacement method.

Moisture content was determined separately for wood and bark on main stem and branch samples. Samples were dried to a constant weight at 103° C., and moisture content was computed on an ovendry basis. The computed moisture content values were used to compute ovendry weight of each component from green weight.

Percent bark was determined on a weight basis from disks and cross-section samples of each tree component. Tree moisture content and specific gravity were calculated by weighting the sample disks in proportion to the volume of the component they represented.

Analysis

Simple linear regression equations were developed to predict green and dry weights of the complete tree as well as each tree component--needles, wood, and bark. The independent variables in these equations were d.b.h., d.b.h. and total height, and d.b.h. and merchantable height. Since the variances in these relationships were found to be proportional to the mean, a logarithmic transformation was used to improve homogeneity of the variance and thus meet the basic assumption of regression analysis. The final form of the regression equation developed was:

$$\text{Log}_{10} Y = b_0 + b_1 \text{Log}_{10} x_i$$

where: Y = tree or tree component weights
$x_1 = D^2$ (diameter at breast height)
$x_2 = D^2Mh$ (diameter at breast height x merchantable height)
$x_3 = D^2Th$ (diameter at breast height x total tree height).

Only equations using d.b.h. and total height will be presented in this paper. The equations using D^2 alone and D^2Mh are available upon request from the Southeastern Forest Experiment Station, Utilization and Technical Characteristics of Southern Softwoods Work Unit, Forestry Sciences Laboratory, Carlton Street, Athens, Georgia 30602.

The aboveground biomass of a tree can be viewed and analyzed in numerous ways. In this study the total tree was subdivided in four ways: (1) wood, bark, foliage, and water, (2) wood, bark, and foliage where water is an integral part of each component, (3) main stem and crown, and (4) main stem, branches, and foliage. We also analyzed the crown as a separate entity having three components (needles, branchwood, and branchbark); the branches by size (small, medium, and large); and the main stem with two components (wood and bark).

Results

Total Tree

If the green tree is visualized as wood, bark, foliage, and water, about one-half of the tree is water. Water proportion changes very little with tree size, ranging from 50 percent in 6-inch trees to a high of 52 percent in the 20-inch trees. Ovendry wood makes up the second largest component of the tree, accounting for about 42 percent of the tree. Ovendry bark and needle components both decrease as tree size increases. Bark decreased from 8 percent in small trees to 5 percent in large trees and needles dropped from 3 percent of the total weight in small trees to 1 percent in large trees. Table 2 shows the weight and proportion of tree components by diameter classes.

If the green tree is viewed as wood, bark, and foliage with water as an integral part of each component, green wood weight makes up 80 to 89 percent of the total tree, the low proportions apply to small trees and the high proportions to large trees (Table 3). The rise in proportion of wood with increasing tree size is 9 percent when water is considered part of the wood, and only 3 percent when wood is ovendried. Green bark decreases with tree size, ranging from 14 percent in small trees to 8 percent in large trees. Here again, the magnitude of the change between large and small trees is about three times as great (6 percent) as the change shown for dry bark. Needles showed the same trend as bark, decreasing from 6 percent in small trees down 3 percent in large trees.

Viewing the tree as a main stem (up to a 2-inch top) and a crown (branches and needles), no apparent trends in weight occurred with changes in tree size (Table 4). Main stem green weight fluctuated between 81 and 86 percent, averaging about 84 percent of the green weight of the tree, crown making up 16 percent. Dry weight of complete stem and crown varied essentially the same amount as green weight--between 81 and 87 percent.

If the tree is broken down into stem, branches, and foliage, the main stem makes up 84 percent of the tree. Branches make up 13 percent and needles 3 percent in both the green and dry condition.

When the crown was considered as a complete unit no trend in weight change was apparent with changing tree size; however, when the crown was divided into branches and needles, some very distinct trends appeared (Table 5). The branches, for instance, made up 11 percent of small-tree weight and 14 to 15 percent of large-tree weight. As the tree became larger, the proportion of large branches increased. Foliage, on the other hand, showed a decreasing trend with tree size ranging from 6 percent down to 3 percent of tree weight of large trees.

Crown

The crown component of the tree, which is generally left behind after logging, makes up about 16 percent of the green weight. In this portion of the tree, needles make up from 17 to 33 percent of the green weight and branches from 67 to 83 percent (Table 6). The proportion of branches in the crown increases with increasing tree size. This trend is due to the increase in the amount of large branches in larger trees and the lack of branches larger than 2 inches d.o.b. in small trees. The trend with increasing tree size shown for green weight is the same for dry weight (Table 7).

Tables 6 and 7 also show the proportion of wood and bark contained in the branch portion of the crown. Green branchwood makes up 71 to 84 percent of the branches and bark from 16 to 29 percent. Small trees which do not have large branches in the crown have the highest percentage of bark. Bark percentage decreases with increasing tree size and the wood fraction increases.

Dry weight of wood varied from 74 to 84 percent in the crown, and bark from 16 to 26 percent. The ratios developed for green and dry weights are slightly different in same diameter classes because of the difference in moisture contents of wood and bark.

Branches

Branches make up 10 to 15 percent of total tree weight, depending on tree size. On the average, 20 percent of branch weight is in small branches, 19 percent medium branches, and 61 percent in large branches. These proportions by branch size vary with tree size rather dramatically (Figure 1). The proportion of large branches increases rapidly with increasing tree size, varying from zero percent in 6-inch trees to a high of 70 percent in 20-inch stems. The medium and small branches show a steady decline with increasing tree size.

When branches are separated into wood and bark, small branches contain 63 percent wood and 37 percent bark, medium branches 77 percent wood, and 23 percent bark, and large branches 88 percent wood and 12 percent bark. If these wood percentages in branches are transposed to show what proportion of the total tree wood is in the various branch sizes, we find 1.9 percent in branches less than 0.6 inch, 2.2 percent in branches greater than 0.6 inch but less than 2.0 inches, and 8.0 percent in branches above 2.0 inches.

Merchantable Stem

The main stem, which in the past was the only part of the tree utilized, contains 87 to 93 percent green wood and 13 to 7 percent green bark, depending on tree size (Table 8). Large trees have the highest proportion of wood and lowest proportion of bark. On a dry basis, trends are the same, but dry ratios differ from the green ones by about 2 percent. Dry wood makes up 84 to 91 percent of the dry weight of the main stem and bark 9 to 16 percent. The differences between green and dry weight ratios are due to the difference in moisture content of wood and bark. In this study, the average moisture content of wood was 107 percent and bark 65 percent. The difference in ratios developed for green and dry material of this type is substantial, and users of such data should know whether computations were made on a green or dry basis.

Specific Gravity and Moisture Content

In addition to green and dry weight, wood specific gravity and moisture content were determined for the total tree, main stem, and branches (Table 9). Total tree specific gravity averaged 0.472 and ranged from 0.453 to 0.488. Specific gravity of the main stem shows essentially the same average of 0.474 and range. Since wood in the main stem makes up about 85 percent of the total tree, it controls the tree specific gravity. Branch specific gravity was lower than main stem, averaging 0.449 and ranging from 0.437 to 0.459. There were no specific trends with tree size.

Bark specific gravity was lower than wood specific gravity, averaging 0.327 for total tree, and 0.329 for main stem. Branchbark specific gravity was lower than that for bark on the main stem, averaging 0.314. There were no trends in bark specific gravity with tree size.

Moisture content of all wood in the tree ranged between 100 and 113 percent and averaged 107 percent. Main-stem moisture content again reflected the same response as total tree, averaging 108 percent and varying between 99 and 115 percent. Branchwood moisture content was lower, averaging 100 percent and ranging between 92 and 108 percent.

Bark displayed a lower moisture content than wood, averaging 75 percent for total tree, 65 percent for main stem, and 114 percent for branches. The relative thickness of the branchbark and differences in ratio of inner to outer bark are reasons for the higher moisture content of branchbark.

Equations

Since a tree can be viewed from a variety of aspects, a series of prediction equations were developed to estimate total tree weight and weight of component parts green and dry. The equations are shown in Table 10, together with their coefficients of determination, standard errors of estimate, and coefficients of variation. The coefficients of determination indicate a high degree of linear association between D^2Th and component weight in most cases. Poorest association occurred in equations developed to predict crown components such as bark in branchlets less than 0.6 inch d.i.b. or branchlets themselves. Crown components had a higher degree of variability than other tree components as is indicated by their coefficients of variation.

For optimum performance, these equations should be applied to timber of similar form and wood properties.

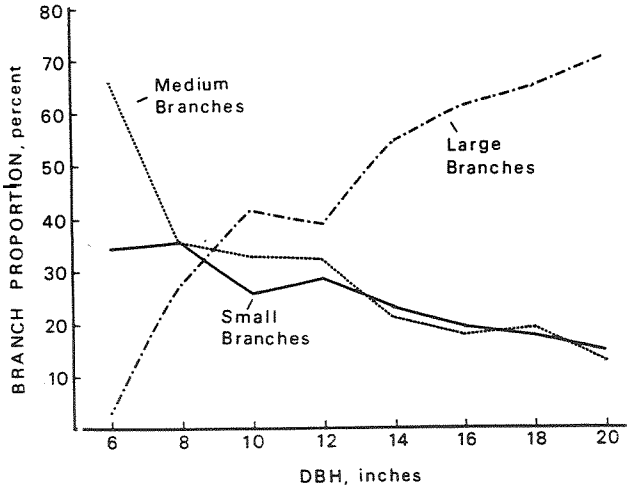

Figure 1.--Proportion of branches in crown by size classes

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Table 1.--Means and ranges of tree measurement in each d.b.h. stratum sampled

D.b.h. class (in.)	Trees sampled (no.)	D.b.h. Avg. (in.)	D.b.h. Range (in.)	Total height Avg. (ft.)	Total height Range (ft.)	Merchantable height[1] Avg. (ft.)	Merchantable height[1] Range (ft.)	Age Avg. (yrs.)	Age Range (yrs.)	Form class Avg.	Form class Range
6	3	6.0	5.6- 6.5	52	48- 57	--	--	38	37-38	--	--
8	3	7.9	7.7- 8.1	60	55- 65	--	--	40	38-41	--	--
10	7	10.0	9.8-10.3	75	63- 85	44	40-55	41	31-45	79	72-83
12	4	12.1	11.9-12.3	78	71- 88	50	46-56	36	31-45	76	72-78
14	6	14.0	13.8-14.2	88	81- 94	65	61-69	43	41-47	80	77-85
16	6	16.1	15.8-16.4	92	82- 99	67	61-79	41	38-44	81	75-85
18	6	17.9	17.6-18.4	91	84- 96	65	53-71	44	38-46	80	77-83
20	6	20.1	19.8-20.4	101	94-107	75	65-81	44	43-47	82	79-86
Study avg.	-	13.9	--	--	--	61	--	42	--	80	--
Total	41										

[1] height to 6-inch d.i.b. top or degrading quality indicators

Table 2.--Average total-tree weight and proportion of aboveground wood, bark, needles, and water in loblolly pine trees 6 to 20 inches d.b.h.

D.b.h. class (in.)	Average total height (ft.)	Trees sampled (no.)	Total tree green weight (lbs.)	Weight and (Proportion) of tree components: Ovendry weight: Wood lbs. (%)	Ovendry weight: Bark lbs. (%)	Ovendry weight: Needles lbs. (%)	Water lbs. (%)
6	52	3	336	132 (39)	28 (8)	9 (3)	167 (50)
8	60	3	626	253 (41)	45 (7)	15 (2)	313 (50)
10	75	7	1270	542 (43)	82 (6)	22 (2)	624 (49)
12	78	4	1787	714 (40)	109 (6)	39 (2)	925 (52)
14	88	6	2984	1264 (42)	166 (6)	53 (2)	1501 (50)
16	92	6	4016	1703 (42)	220 (6)	65 (2)	2028 (50)
18	91	6	5005	2068 (41)	269 (5)	93 (2)	2575 (52)
20	101	6	6982	2925 (42)	325 (5)	95 (1)	3637 (52)
Study avg.	-	-	3241	1356 (42)	174 (5)	54 (2)	1657 (51)

Table 3.--Average total-tree green weight and proportion of aboveground wood, bark, and needles for loblolly pine trees 6 to 20 inches d.b.h.

D.b.h. class (in.)	Average total height (ft.)	Trees sampled (no.)	Total tree green weight (lbs.)	Tree components - Green weight: Wood lbs. (%)	Bark lbs. (%)	Needles lbs. (%)
6	52	3	336	269 (80)	48 (14)	19 (6)
8	60	3	626	519 (83)	77 (12)	30 (5)
10	75	7	1270	1081 (85)	144 (11)	45 (4)
12	78	4	1787	1515 (85)	194 (11)	78 (4)
14	88	6	2984	2579 (86)	295 (10)	110 (4)
16	92	6	4016	3503 (87)	383 (10)	130 (3)
18	91	6	5005	4354 (87)	466 (9)	185 (4)
20	101	6	6982	6209 (89)	572 (8)	201 (3)
Study avg.	-	-	3241	2827 (87)	304 (10)	110 (3)

Table 4.--Average total-tree green and dry weight and proportion of tree in main stem and crown for loblolly pine trees 6 to 20 inches d.b.h.

D.b.h. class (in.)	Trees sampled (no.)	Average total height (ft.)	Total tree weight (lbs.)	Stem[1] Weight (lbs.)	Stem[1] Proportion (%)	Crown[2] Weight (lbs.)	Crown[2] Proportion (%)
				GREEN			
6	3	52	336	279	83	57	17
8	3	60	626	531	85	95	15
10	7	75	1270	1095	86	175	14
12	4	78	1787	1503	84	284	16
14	6	88	2984	2525	85	459	15
16	6	92	4016	3390	84	626	16
18	6	91	5005	4075	81	930	19
20	6	101	6982	5828	83	1154	17
Study avg.	-	-	3241	2707	84	534	16
				DRY			
6	3	52	169	141	83	28	17
8	3	60	312	265	85	47	15
10	7	75	646	561	87	85	13
12	4	78	862	720	84	142	16
14	6	88	1483	1258	84	225	16
16	6	92	1988	1672	84	316	16
18	6	91	2430	1978	81	452	19
20	6	101	3345	2780	83	565	17
Study avg.	-	-	1583	1321	83	262	17

[1] stem material to 2-inch top
[2] includes branch material, needles, and tip of stem

Table 5.--Average total-tree green and dry weight and proportions in the main stem, branches, and needles in loblolly pine trees 6 to 20 inches d.b.h.

D.b.h. class (in.)	Trees sampled (no.)	Average total height (ft.)	Total tree weight (lbs.)	Tree Components: Weight Stem (lbs.)	Weight Branches (lbs.)	Weight Needles (lbs.)	Proportion Stem (%)	Proportion Branches (%)	Proportion Needles (%)
					GREEN				
6	3	52	336	279	38	19	83	11	6
8	3	60	626	531	65	30	85	10	5
10	7	75	1270	1095	130	45	86	10	4
12	4	78	1787	1503	207	77	84	12	4
14	6	88	2984	2525	349	110	85	12	3
16	6	92	4016	3390	495	131	84	12	4
18	6	91	5005	4075	745	185	81	15	4
20	6	101	6982	5828	953	201	83	14	3
Study avg.	-	-	3241	2707	424	110	84	13	3
					DRY				
6	3	52	169	141	19	9	83	11	6
8	3	60	312	265	32	15	85	10	5
10	7	75	646	561	63	22	87	10	3
12	4	78	862	720	103	39	84	12	4
14	6	88	1483	1258	172	53	84	12	4
16	6	92	1988	1672	251	65	84	13	3
18	6	91	2430	1978	359	93	81	15	4
20	6	101	3345	2780	470	95	83	14	3
Study avg.	-	-	1583	1321	208	54	84	13	3

Table 6.--Crown green weight and proportion of needles, branchwood, and branchbark in loblolly pine trees 6 to 20 inches d.b.h.

D.b.h. class	Trees sampled	Average total height	Crown[1]				
			Complete crown	Needles	Branches Wood & Bark	Branchwood	Branchbark
(in.)	(no.)	(ft.)	lbs. (%)				
6	3	52	57	19 (33)	38 (67)	27 (71)	11 (29)
8	3	60	95	30 (32)	65 (68)	46 (71)	19 (29)
10	7	75	175	45 (26)	130 (74)	97 (75)	33 (25)
12	4	78	284	78 (27)	206 (73)	150 (73)	56 (27)
14	6	88	459	110 (24)	349 (76)	279 (80)	70 (20)
16	6	92	626	131 (21)	495 (79)	394 (80)	101 (20)
18	6	91	930	185 (20)	745 (80)	601 (81)	144 (19)
20	6	101	1154	201 (17)	953 (83)	799 (84)	154 (16)
Study avg.	-	-	534	110 (20)	424 (80)	341 (81)	83 (19)

[1] includes tip of stem

Table 7.--Crown dry weight and proportion of needles, branchwood, and branchbark in loblolly pine trees 6 to 20 inches d.b.h.

D.b.h. class	Trees sampled	Average total height	Crown[1]				
			Complete crown	Needles	Branches Wood & Bark	Branchwood	Branchbark
(in.)	(no.)	(ft.)	lbs. (%)				
6	3	52	28	9 (32)	19 (68)	14 (74)	5 (26)
8	3	60	47	15 (32)	32 (68)	23 (72)	9 (28)
10	7	75	85	22 (26)	63 (74)	48 (76)	15 (24)
12	4	78	142	39 (27)	103 (73)	78 (76)	25 (24)
14	6	88	225	53 (24)	172 (76)	141 (82)	31 (18)
16	6	92	316	65 (21)	251 (79)	202 (80)	49 (20)
18	6	91	452	93 (21)	359 (79)	290 (81)	69 (19)
20	6	101	565	95 (17)	470 (83)	396 (84)	74 (16)
Study avg.	-	-	262	54 (21)	208 (79)	169 (81)	39 (19)

[1] includes tip of stem

Table 8.--Main stem[1/] green and dry weight and proportion of wood and bark in loblolly pine trees 6 to 20 inches d.b.h.

D.b.h. class	Trees sampled	Average total height	Main stem weight	Stemwood		Stembark	
				Weight	Proportion	Weight	Proportion
(in.)	(no.)	(ft.)	(lbs.)	(lbs.)	(%)	(lbs.)	(%)
				GREEN			
6	3	52	279	242	87	37	13
8	3	60	531	473	89	58	11
10	7	75	1095	984	90	111	10
12	4	78	1503	1365	91	138	9
14	6	88	2525	2300	91	225	9
16	6	92	3390	3108	92	282	8
18	6	91	4075	3753	92	322	8
20	6	101	5828	5409	93	419	7
Study avg.	-	-	2707	2486	92	221	8
				DRY			
6	3	52	141	118	84	23	16
8	3	60	265	230	87	35	13
10	7	75	561	494	88	67	12
12	4	78	720	636	88	84	12
14	6	88	1258	1123	89	135	11
16	6	92	1672	1501	90	171	10
18	6	91	1978	1778	90	200	10
20	6	101	2780	2529	91	251	9
Study avg.	-	-	1321	1186	90	135	10

[1/] stem material to 2-inch d.i.b. top

Table 9.--Average wood and bark specific gravity and moisture content for the total tree, main stem, and branches by diameter class of loblolly pine trees 6 to 20 inches d.b.h.

D.b.h. class	Trees sampled	Total height	Wood			Bark		
			Total tree	Main stem	Branches	Total tree	Main stem	Branches
(in.)	(no.)	(ft.)						
					SPECIFIC GRAVITY			
6	3	52	.474	.477	.442	.331	.329	.337
8	3	60	.479	.483	.438	.339	.344	.316
10	7	75	.488	.493	.443	.337	.342	.315
12	4	78	.453	.455	.437	.304	.306	.296
14	6	88	.477	.480	.457	.327	.332	.301
16	6	92	.476	.478	.459	.330	.333	.318
18	6	91	.463	.465	.446	.325	.325	.318
20	6	101	.457	.457	.457	.320	.320	.319
Study avg.	-	-	.472	.474	.449	.327	.327	.314
					MOISTURE CONTENT			
			- - - - - - - - - -		- - - (percent) - - -		- - - - - - - - - -	
6	3	52	104	105	95	72	66	98
8	3	60	105	106	97	74	63	117
10	7	75	100	99	105	74	65	115
12	4	78	112	114	92	78	64	125
14	6	88	104	105	97	78	68	123
16	6	92	106	107	95	74	65	108
18	6	91	110	111	108	73	61	114
20	6	101	113	115	102	76	66	109
Study avg.	-	-	107	108	100	75	65	114

Table 10.--Regression equations for estimating green and dry weight of the aboveground portion of natural loblolly pine trees 6 to 20 inches d.b.h., and tree component parts using d.b.h. and total height as the independent variables

Weight (Y)	Regression Equation[1]	Coefficient of determination (R^2)	Standard error[2]	Coefficient of variation (CV)
TOTAL TREE[3]				
1. Green	$Log_{10} Y = -0.78974 + 1.00404\ Log_{10} D^2TH$	0.99	.0459	1.4
2. Dry	$Log_{10} Y = -1.02930 + 0.98788\ Log_{10} D^2TH$	0.99	.0446	1.5
TOTAL TREE (excluding needles)[3]				
3. Green	$Log_{10} Y = -0.83678 + 1.01136\ Log_{10} D^2TH$	0.99	.0455	1.4
4. Dry	$Log_{10} Y = -1.07200 + 0.99421\ Log_{10} D^2TH$	0.99	.0446	1.5
ALL WOOD IN TREE[3]				
5. Green	$Log_{10} Y = -0.97711 + 1.03321\ Log_{10} D^2TH$	0.99	.0472	1.4
6. Dry	$Log_{10} Y = -1.23050 + 1.01839\ Log_{10} D^2TH$	0.99	.0482	1.6
ALL BARK IN TREE[3]				
7. Green	$Log_{10} Y = -1.09048 + 0.83768\ Log_{10} D^2TH$	0.97	.0537	2.3
8. Dry	$Log_{10} Y = -1.31957 + 0.83444\ Log_{10} D^2TH$	0.98	.0514	2.4
WOOD AND BARK IN STEM FROM STUMP TO 6" D.I.B. TOP FOR TREES > 9.5" D.B.H.[4]				
9. Green	$Log_{10} Y = -1.13563 + 1.06027\ Log_{10} D^2TH$	0.98	.0449	1.3
10. Dry	$Log_{10} Y = -1.26103 + 1.01834\ Log_{10} D^2TH$	0.97	.0440	1.4
WOOD IN STEM FROM STUMP TO 6" D.I.B. TOP FOR TREES > 9.5" D.B.H.[4]				
11. Green	$Log_{10} Y = -1.25051 + 1.07799\ Log_{10} D^2TH$	0.97	.0470	1.4
12. Dry	$Log_{10} Y = -1.38760 + 1.03649\ Log_{10} D^2TH$	0.97	.0474	1.6
BARK IN STEM FROM STUMP TO 6" D.I.B. TOP FOR TREES > 9.5" D.B.H.[4]				
13. Green	$Log_{10} Y = -1.40406 + 0.87245\ Log_{10} D^2TH$	0.94	.0576	2.5
14. Dry	$Log_{10} Y = -1.58201 + 0.86453\ Log_{10} D^2TH$	0.94	.0580	2.7
WOOD AND BARK IN STEM FROM STUMP TO 2" D.I.B. TOP[3]				
15. Green	$Log_{10} Y = -0.84452 + 0.99901\ Log_{10} D^2TH$	0.99	.0401	1.2
16. Dry	$Log_{10} Y = -1.07051 + 0.97960\ Log_{10} D^2TH$	0.99	.0408	1.4
WOOD IN STEM FROM STUMP TO 2" D.I.B. TOP[3]				
17. Green	$Log_{10} Y = -0.96714 + 1.01849\ Log_{10} D^2TH$	0.99	.0423	1.3
18. Dry	$Log_{10} Y = -1.21481 + 1.00184\ Log_{10} D^2TH$	0.99	.0450	1.5
BARK IN STEM FROM STUMP TO 2" D.I.B. TOP[3]				
19. Green	$Log_{10} Y = -1.13045 + 0.81560\ Log_{10} D^2TH$	0.98	.0503	2.2
20. Dry	$Log_{10} Y = -1.34626 + 0.81541\ Log_{10} D^2TH$	0.97	.0522	2.6
CROWN WEIGHT (includes branchwood, branchbark, and needles)[3]				
21. Green	$Log_{10} Y = -1.68007 + 1.02412\ Log_{10} D^2TH$	0.92	.1213	4.7
22. Dry	$Log_{10} Y = -1.98746 + 1.02416\ Log_{10} D^2TH$	0.92	.1176	5.2
NEEDLES[3]				
23. Green	$Log_{10} Y = -1.54968 + 0.83959\ Log_{10} D^2TH$	0.88	.1242	6.4
24. Dry	$Log_{10} Y = -1.87201 + 0.84237\ Log_{10} D^2TH$	0.88	.1212	7.5
WOOD AND BARK IN ALL BRANCH MATERIAL[3]				
25. Green	$Log_{10} Y = -2.06598 + 1.08816\ Log_{10} D^2TH$	0.91	.1321	5.4
26. Dry	$Log_{10} Y = -2.35672 + 1.08442\ Log_{10} D^2TH$	0.91	.1299	6.1
WOOD IN ALL BRANCH MATERIAL[3]				
27. Green	$Log_{10} Y = -2.41930 + 1.14664\ Log_{10} D^2TH$	0.91	.1376	5.9
28. Dry	$Log_{10} Y = -2.68566 + 1.13854\ Log_{10} D^2TH$	0.92	.1334	6.6
BARK IN ALL BRANCH MATERIAL[3]				
29. Green	$Log_{10} Y = -1.90850 + 0.89103\ Log_{10} D^2TH$	0.89	.1255	7.0
30. Dry	$Log_{10} Y = -2.23084 + 0.88960\ Log_{10} D^2TH$	0.88	.1304	8.9
WOOD AND BARK IN BRANCH MATERIAL > 2.0" D.O.B.[5]				
31. Green	$Log_{10} Y = -4.02549 + 1.48325\ Log_{10} D^2TH$	0.84	.1704	7.4
32. Dry	$Log_{10} Y = -4.28299 + 1.47039\ Log_{10} D^2TH$	0.84	.1693	8.5
WOOD IN BRANCH MATERIAL > 2.0" D.O.B.[5]				
33. Green	$Log_{10} Y = -4.25184 + 1.52092\ Log_{10} D^2TH$	0.85	.1721	7.7
34. Dry	$Log_{10} Y = -4.51616 + 1.50864\ Log_{10} D^2TH$	0.84	.1722	9.0

Table 10.--Regression equations for estimating green and dry weight of the aboveground portion of natural loblolly pine trees 6 to 20 inches d.b.h., and tree component parts using d.b.h. and total height as the independent variables (continued)

Weight (Y)	Regression Equations[1]	Coefficient of determination (R^2)	Standard error[2]	Coefficient of variation (CV)
BARK IN BRANCH MATERIAL > 2.0" D.O.B.[5]				
35. Green	$\text{Log}_{10} Y = -3.88692 + 1.24823 \text{ Log}_{10} D^2TH$	0.78	.1758	12.2
36. Dry	$\text{Log}_{10} Y = -4.19673 + 1.25283 \text{ Log}_{10} D^2TH$	0.77	.1813	15.7
WOOD AND BARK IN BRANCH MATERIAL ≥ 0.6" and <2.0" D.O.B.[3]				
37. Green	$\text{Log}_{10} Y = -0.77124 + 0.62652 \text{ Log}_{10} D^2TH$	0.75	.1420	7.8
38. Dry	$\text{Log}_{10} Y = -1.12168 + 0.63794 \text{ Log}_{10} D^2TH$	0.72	.1545	10.1
WOOD IN BRANCH MATERIAL ≥ 0.6" AND < 2.0" D.O.B.[3]				
39. Green	$\text{Log}_{10} Y = -0.96272 + 0.64408 \text{ Log}_{10} D^2TH$	0.75	.1468	8.6
40. Dry	$\text{Log}_{10} Y = -1.34480 + 0.66677 \text{ Log}_{10} D^2TH$	0.74	.1555	10.9
BARK IN BRANCH MATERIAL ≥ 0.6" AND < 2.0" D.O.B.[3]				
41. Green	$\text{Log}_{10} Y = -1.15009 + 0.56554 \text{ Log}_{10} D^2TH$	0.68	.1514	12.7
42. Dry	$\text{Log}_{10} Y = -1.34085 + 0.52558 \text{ Log}_{10} D^2TH$	0.59	.1720	20.5
WOOD AND BARK IN BRANCH MATERIAL < 0.6" D.O.B.[3]				
43. Green	$\text{Log}_{10} Y = -1.62183 + 0.82754 \text{ Log}_{10} D^2TH$	0.87	.1244	6.9
44. Dry	$\text{Log}_{10} Y = -1.99930 + 0.84664 \text{ Log}_{10} D^2TH$	0.89	.1194	7.9
WOOD IN BRANCH MATERIAL < 0.6" D.O.B.[3]				
45. Green	$\text{Log}_{10} Y = -1.90933 + 0.84701 \text{ Log}_{10} D^2TH$	0.87	.1276	8.0
46. Dry	$\text{Log}_{10} Y = -2.29065 + 0.87382 \text{ Log}_{10} D^2TH$	0.89	.1215	9.1
BARK IN BRANCH MATERIAL <0.6" D.O.B.[3]				
47. Green	$\text{Log}_{10} Y = -1.89534 + 0.79054 \text{ Log}_{10} D^2TH$	0.84	.1361	9.8
48. Dry	$\text{Log}_{10} Y = -2.23832 + 0.78894 \text{ Log}_{10} D^2TH$	0.84	.1362	13.2
WOOD AND BARK IN BRANCH MATERIAL < 2.0" D.O.B.[3]				
49. Green	$\text{Log}_{10} Y = -0.85520 + 0.71848 \text{ Log}_{10} D^2TH$	0.84	.1228	5.8
50. Dry	$\text{Log}_{10} Y = -1.21260 + 0.73214 \text{ Log}_{10} D^2TH$	0.84	.1271	7.0
WOOD IN BRANCH MATERIAL <2.0" D.O.B.[3]				
51. Green	$\text{Log}_{10} Y = -1.05160 + 0.72748 \text{ Log}_{10} D^2TH$	0.83	.1271	6.5
52. Dry	$\text{Log}_{10} Y = -1.44695 + 0.75540 \text{ Log}_{10} D^2TH$	0.84	.1285	7.6
BARK IN BRANCH MATERIAL <2.0" D.O.B.[3]				
53. Green	$\text{Log}_{10} Y = -1.29302 + 0.69933 \text{ Log}_{10} D^2TH$	0.83	.1255	7.8
54. Dry	$\text{Log}_{10} Y = -1.52236 + 0.66946 \text{ Log}_{10} D^2TH$	0.79	.1351	10.8

[1] $\text{Log}_{10} Y = b_0 + b_1 \text{ Log}_{10} D^2TH$ Where: Y = weight in pounds, D = d.b.h. in inches, TH = total height in feet

[2] standard error of estimate in Log_{10} form

[3] regression equations based on 41 trees 6 to 20 inches d.b.h.

[4] regression equations based on 35 trees 10 to 20 inches d.b.h.

[5] regression equations based on 38 trees 8 to 20 inches d.b.h.

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